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"Spirit of Electricity"—By Evelyn A. Longman

STEINMETZ: GENIUS OF ELECTRICITY
GIANT SPIDER WEBS OF STEEL

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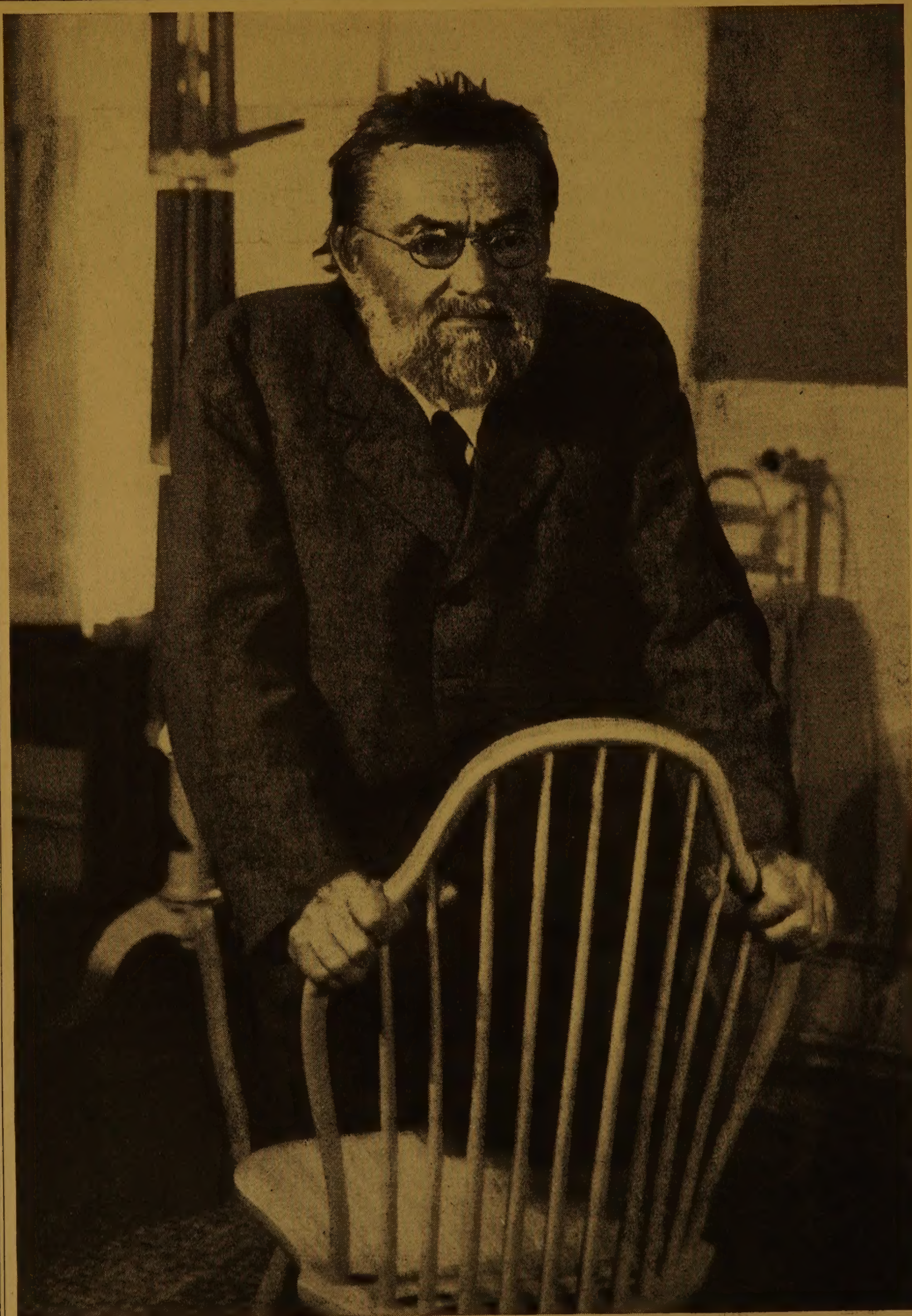
CHARLES P. STEINMETZ

THE STORY OF HIS LIFE AND WORK
BY JOHN WINTHROP HAMMOND

CHARLES P. STEINMETZ IN HIS OFFICE

HE WAS *called a "wizard," a "worker of miracles," and a "modern Jove who made lightning and thunderbolts"—titles that he heartily disliked. As a matter of fact, he was a plain, modest man and his life and habits were simple. In the field of applied mathematics he stood supreme. His "miracles" were mathematical achievements, his "wizardry" an infallible, logical mental process. A human paradox: great genius indwelling a dwarfed body; a master mind surmounting a shy and gentle nature.*



International News Reel

CHARLES P. STEINMETZ

From a photograph taken in New York City about 1920

The MENTOR

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MAY, 1925

CHARLES PROTEUS STEINMETZ

By

JOHN WINTHROP HAMMOND

Biographer of Charles P. Steinmetz

Photograph by Rudolf Eickemeyer, Jr.

RUDOLF EICKEMEYER

Steinmetz's first employer, to whom he always felt he owed much for starting him on a definite career. Eickemeyer was himself an inventor and prominent manufacturer in Yonkers, New York

A man of peace and good will, yet willing to suffer for his convictions; endowed with marvelous talents in mathematics, and for years a master builder of electrical engineering, Steinmetz, in his comparatively brief life of less than sixty years, contributed imperishably to modern civilization.

But his early days gave little promise of all this. His people were not conspicuous. His home was moderately comfortable, but humble. Almost his only advantage was a discerning, unselfish father, who encouraged him to win an education. And the education had to be "won" in a very real sense.

Steinmetz was born on April 9, 1865, at Breslau, province of Silesia. His parents were Carl Heinrich and Caroline (Neubert) Steinmetz. Carl Heinrich was chief of the lithographing department of the Ober Schlesische railroad, which had its general offices at Breslau. He was skilled in his trade, a man interested in technical matters, well posted on the scientific events of his time.

The son, who was the only boy in the household, was christened Carl August Rudolph Steinmetz, after his father and his two uncles. A tragic shadow hung over him from the very first, for he was born a cripple, and all his life he remained a dwarf. But he was remarkably healthy none the less, and his disposition was naturally placid and sympathetic.

He was carefully reared. The truth is, he was very nearly spoiled by his grandmother. She it was who brought him up, for his mother died when he was a year old. "Grossmutter" made much of the little crippled grandson, calling him by a pet name, Carluszek, and constantly showing him undue leniency, even when he got into mischief.

CARL HEINRICH STEINMETZ
Father of a famous son

She was equally indulgent when, at the age of four, Carluszek protested against being sent to kindergarten. He spent one-half day at this new, strange place, but sorely missed the good things at home. His tearful outcry led Grossmutter to put off the beginning of his schooling for another year.

According to Carl's sister, Miss Clara W. Steinmetz, he was something of a prodigy in the way he took to figures. By five or six he could do fractions. But we have it from his own story that his first encounter with the multiplication tables was a demoralizing experience. He found them difficult to master. They required greater mental application than he had ever before been called upon to put forth. His progress was so uncertain for a while that his teachers were not at all impressed by his ability.

But all this was changed by the time he was fifteen. He was then well into the classical gymnasium (high school), which admitted to any of the universities. His thirst for knowledge had been awakened and his extraordinary mathematical leanings had made their appearance.

With increasing eagerness he advanced swiftly in his studies, displaying a zest that soon amounted to an absorbing passion.

In the latter years of his gymnasium course he studied the classical languages, learning Homer and Horace so thoroughly that thirty years later he could still recite long passages from their works without an error.

Carl's father watched his progress keenly and made a companion of him. He threw open to the young man every scrap of material that he himself possessed—summed up in the few score volumes of a modest scientific library that was not lacking in quality, if rather meager in quantity.

The elder Steinmetz continued his quiet, companionable pride in his son when the young man, in 1882, entered the University of Breslau. As time went on he observed that Carl's lecture notes were accumulating rapidly, and at length he took these loose sheets and bound them into notebooks.

Steinmetz kept these notebooks all his life. They included memoranda of the university lectures, original mathematical work, and independent problems which he investigated in a crude little laboratory set up in his room at home. The notes and diagrams are recorded with neatness in careful German script, with indelible ink.

As he went on with his studies he distinguished himself more and more by

his accomplishments. In his final year at the university he was specializing in six major subjects: Higher mathematics, astronomy, theoretical physics, chemistry, medicine, and electrical engineering.

He undertook such intensive work because he enjoyed it. This was particularly true of mathematics, and to some extent of physics and chemistry. But he was not a mere "grind" in study. He was too gregarious by nature, too fond of companionship for that.

At Breslau, as at most German universities, it was the universal custom to join one of several student societies. Steinmetz fell in with this practice by immediately becoming a member of the student mathematical society. And thereby he found a social atmosphere that fairly delighted his soul.

During the first year he was numbered among the "foxes"—meaning the first-year men, who corresponded to the "freshies" of an American college. They were without any recognized standing among the other students, were bound by many strict rules, and were governed at meetings of the mathematical society by a "fox major," whom they were required to obey unquestionably. If the evening threatened to grow dull it was the foxes who had to entertain with impromptu songs or stories. Such moments as these were disconcerting to Steinmetz, for he could not sing and knew but few stories.

However, as his first year passed, he enjoyed the meetings of the mathe-

STUDENTS ✤ AT BRESLAU

The students of the University of Breslau often made merry, meeting in restaurants in the winter and going on excursions in the summer. This is one of the few photographs of Steinmetz as a young man. He is shown standing on the extreme right

The Century Company, N. Y.

STEINMETZ IN 1890

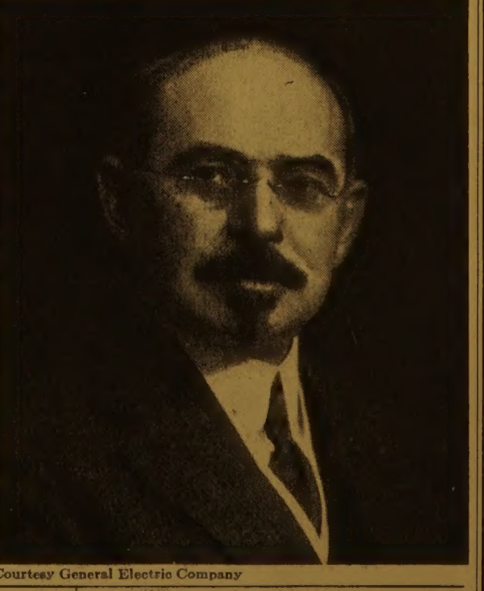
Taken prior to his epochal papers before the American Institute of Electrical Engineers on the law of "hysteresis." This was during his period of employment by Rudolf Eickemeyer at Yonkers

matical society as much as the rest of them. The programs were long and varied. They started with a staid business session, followed by a technical hour, during which mathematical problems were discussed. Then everybody relaxed and became jovial. Steinmetz was not backward in helping on these genial affairs.

The others had stood in awe of his scholastic zeal at first. Then they found that he was a good mixer and a pleasant companion. What wonder, then, that they recognized a versatility uncommon among their number by giving him the nickname of "Proteus"—signifying one who can play various rôles!

At no time was he well off as to funds. His father encouraged him in his studies, but could not help him much financially. So Carl took to tutoring to pay his tuition fees. And while he gave instruction to gymnasium boys, and studied earnestly in the university at the same time, he began to observe and brood over some of the social conditions of his own city.

He became convinced that there was much social injustice in the world. The seed of Socialism got into his mind. For a year or two it lay there dormant. Then there came a friendship that nursed it into a conviction that lasted a lifetime. It was during his second year at the university that he met a young fellow named "Heinz" Lux, who invited Steinmetz to attend a secret session of a small group of students having very pronounced ideas concerning social and political issues.



Courtesy General Electric Company

EDWIN WILBUR RICE, JR.

Former president of the General Electric Company, who secured the services of Steinmetz for that company. It was at this time that Steinmetz adopted the profession of electrical engineer

Steinmetz went to this meeting; and from that time forward he was an ardent member of the student Socialist group, which numbered a dozen young fellows and that held gatherings at different homes under the guise of tea parties. This group was constantly in touch with the out-and-out Socialists of Breslau and

THE HOME OF STEINMETZ
In the left foreground appears his private laboratory. On the right is his conservatory, filled with cacti, orchids and ferns, and in front of this is shown a smaller cactus house. His house is in the rear

with the nation-wide organization known as the Social Revolutionary Party.

Gradually the student Socialists became bolder; and before long they were under official suspicion. For several years Steinmetz lived what he afterwards alluded to as "the most exciting period of my life."

The young Socialists of Breslau University attracted attention to themselves by meeting one day to bid farewell to two of their number who were about to go to other cities. And they signalized the occasion by posing for a photograph grouped around a bust of Ferdinand Lassalle, a German Socialist and publicist of national repute.

Then, in an unthinking wave of enthusiasm, they permitted this damaging picture to be displayed in the photographer's window!

This was the beginning of a train of events which ended in the arrest of Lux and more than forty other suspects. Carl Steinmetz thus found himself suddenly obliged to step into the gap as temporary editor of "The People's Voice," the Breslau Socialist paper, the editor of which was among those lodged in jail, awaiting trial. He also endeavored to conduct a fortnightly literary magazine and a technical publication, likewise left helpless by the police round-up.

As both publications were on the verge of bankruptcy, Steinmetz had an exciting time of it for upwards of two months.

One of the articles in "The People's Voice" was altogether too belligerent; and he had printed regularly at the top of his editorial page the unfriendly motto: "We don't know what the government wants, but we disapprove of it." The police were roused to action. The paper was officially banned, its

BICYCLING TO HIS OFFICE
On days when Dr. Steinmetz came into town from his camp, to go to his office, he rode a bicycle, until he finally acquired a motor car. This photograph was taken in 1911. The boy is Joseph Hayden, Steinmetz's oldest adopted grandchild

acting editor closely questioned, and although the officers did not learn who actually wrote the offensive article they suspected him and sent a vigorous complaint to the rector of the university.

For the next few months they began to collect evidence against him and at length prepared to arrest him. At the eleventh hour he was warned, and after a hurried farewell party he reached his home an hour or two before daylight on a May morning in 1888, prepared to flee. Awaking his father, he announced that he was going to Austria to visit a friend; and slipping quietly out of the city on an early train he was in Vienna before another night. A day or two later he reached Zurich.

There he hired lodgings, paid for the room in advance, and spent nearly all his remaining money for food. He wrote his father a letter, explaining his situation, sought a meager living by writing for the papers and tutoring, and made application to enter the Zurich Polytechnic School, where he wanted to study mechanical engineering.

And so we find this brilliant young mathematician, this sociable, likable, quiet young fellow, breaking sharply with every tie he had so far formed in life rather than give up his political principles. He was homesick in Zurich, distressingly poor, and extremely desolate.

Moreover, his one ambition of the moment—to study at the Polytechnic—was temporarily frustrated because he could not comply with a regulation requiring him to present a certificate of residence from the police of his home town.

Steinmetz lived in Zurich the better part of the year. Gradually his circumstances improved. He succeeded in entering the Polytechnic, and studied there for nine months. He earned a slender income writing and tutoring. And he made a bosom friend—a young Dane named Oscar Asmussen, whose rich uncle in California was paying his way at the Polytechnic.

Early in the spring of 1889, Asmussen aroused the displeasure of this uncle by making love to a Zurich maiden instead of devoting himself to his studies. He found his funds suddenly cut off; and, having no alternative, he was obliged forthwith to prepare to sail for America.

Talking over this turn of events with Asmussen, Steinmetz expressed his

desire to visit the great republic across the sea. This remark impelled Asmussen to urge Steinmetz to accompany him, and when Asmussen offered to supply Steinmetz's lack of funds for the trip the latter agreed.

Less than a week later Steinmetz severed all his old ties and yielded to the lure of the New World. After a long but enjoyable passage he found himself, June 1, 1889, standing on the deck of the French immigrant liner *La Champagne*, gazing with wonder at the Statue of Liberty, which loomed before him in the waters of New York Bay.

An odd little figure he presented, trudging down the gangplank beside the nonchalant Asmussen. In addition to his queer, dwarfish figure, his face was swollen with a cold caught during the ocean trip. He had no funds of his own, and despite earnest efforts to learn English on the boat he knew almost nothing of the language. When the immigration inspectors asked him if he could speak English he replied, "A few."

His traveling companion, however, did not desert him in this crisis. Asmussen, in fluent English, offered to be responsible for Steinmetz's welfare, and displayed money which he declared belonged to them both. His representations won the day. Steinmetz, by this rather slender appeal, was admitted. America had gained another genius!

Ten days later we find Steinmetz in the employ of one of the men who had a great deal to do in shaping his career. This man was Rudolf Eicke-

STEINMETZ WITH HIS ADOPTED FAMILY

A rare photograph of Dr. Steinmetz and the Haydens, taken about 1908. In the picture, left to right, are: Mrs. Joseph Leroy Hayden, Billy Hayden, Dr. Steinmetz, Joe Hayden, Marjorie Hayden, and Joseph Leroy Hayden

The Century Company, N. Y.

A CROW FRIEND

Not "Jim Crow" but "John Crow," as Steinmetz named him. This friendly bird would light daily on the window sill of the great man's bedroom to greet him

meyer, a keen-eyed, patriarchal inventor-manufacturer, who was the head of Eickemeyer & Osterheld, in Yonkers, New York. He too had left his native land under political pressure and had made a notable career in America.

Until this time Steinmetz had formed no life program. He did not know what he wanted to do, except that he loved mathematics.

His association with Eickemeyer determined his future. In the Yonkers factory he was at once put to work as a draftsman, making drawings of a motor for electric cars. Before long he was calculating the electrical characteristics of various kinds of apparatus, particularly motors. Eickemeyer had discovered this young man's mathematical ability, had noted his quickly roused enthusiasm, had encouraged him to establish an experimental laboratory—in brief, had begun to help Steinmetz find himself.

And now, in a rude, ill-furnished little one-room laboratory in Eickemeyer's factory, a room unbearably hot in summer and bitterly cold in winter, was wrought one of the great achievements of modern electrical engineering. For Steinmetz, a long-haired, strange-appearing, intensely absorbed young man in his late twenties, was formulating, by profound mathematical processes, a law that ever since has been the basis of all calculations used in the design of electric motors. This law is known as the law of "hysteresis," or the loss of efficiency in an electric motor caused by the increase of magnetization.

Until this time the designers of electric motors were quite in the dark as to the law governing this loss. They never knew in advance how the efficiency of a motor would be affected by hysteresis losses.

But on January 19, 1892, there appeared before the American Institute of Electrical Engineers a dwarfed young man, speaking English with a decided accent, who read a lengthy paper, fairly bristling with mathematical formulæ, and establishing for all time the important technical knowledge which he had discovered. On September 27th of the same year he read a supplementary paper on the same subject, the two papers together covering two hundred pages.

Fairly overnight Steinmetz drew the attention of the entire profession of electrical engineering. Yet with characteristic application to the task in

hand he kept on with his daily work at Eickemeyer's, and almost immediately embarked upon an even more difficult line of technical research. This was his development of a method for making calculations with alternating electrical currents—until that time a sad dilemma to electrical engineers. His solution of this problem came at the psychological moment, when electrical expansion, by means of alternating current, was inevitable, yet woefully retarded because men did not know what Steinmetz had now found out for them.

This intensive work was expounded to electrical engineers, college instructors, college students, and even boys in high school, over a period of years by a masterly series of textbooks, still in use by electrical men throughout the world. They represent the great contribution of Steinmetz to his profession, and through his profession to a world becoming gradually dependent upon the services of electricity.

In the midst of this new activity the Eickemeyer & Osterheld manufacturing business was bought up in 1892 by the General Electric Company, and through the agency of Edwin Wilbur Rice, Jr., later president of General Electric, young Steinmetz's services were secured by the new corporation.

Going from Yonkers to Lynn, then the headquarters of General Electric, Steinmetz quickly won a place for himself in the mathematical division of the organization—the calculating department, as it was termed. For one thing, he brought with him the complete mastery of alternating current

THE SUMMER CAMP

On Viele's Creek, a tributary of the Mohawk River. This view, taken in September, shows the camp as Steinmetz loved it best

The Century Company, N. Y.

THE CAMP AFTER FIFTEEN YEARS

This shows Steinmetz's camp as it finally appeared after several wings had been added. The Doctor and Billy and Joe Hayden are standing in the original portion

calculation, which he alone understood perfectly, and which he imparted by degrees to all the engineers of the General Electric Company.

From 1892 to 1894 he was located in Lynn, Massachusetts, going through the severe panic of '93 while there. Then, in 1894, he and many others were transferred to Schenectady, New York, where the company had established its headquarters.

During these years Steinmetz was gaining a recognized place as a genius in the mathematical department of electrical engineering. From the moment of his arrival in Schenectady, he held a position of value, reorganizing the old calculating department and becoming its official head. Year after year he made engineers familiar with his method of alternating current calculations, in the use of which he always remained the master.

There seemed to be nothing that Steinmetz could not do in mathematics. The most complicated problems had no power to dismay him. His associates again and again were amazed to the point of awe by his almost uncanny ability to do enormous sums in his head and in less than a minute's time. He came to be called upon with increasing frequency to solve mathematical and engineering riddles, to untangle technical questions, and to discover why this or that electrical device would not work, or to ferret out the cause of trouble in new electrical applications when put into practice.

Invariably he attacked these bugbears calmly and successfully, cigar in mouth. Even before coming to Schenectady he was a large consumer of

cigars. When a "No Smoking" sign appeared in the Schenectady offices of the General Electric Company, Steinmetz placidly disregarded it and smoked as hard as ever.

At the moment there was no special incident over this attitude of his but a little romantic legend gradually grew up around it, until to-day in most of the homes of Schenectady and near-by regions the favorite Steinmetz anecdote relates how he stayed home when he found he was not allowed to smoke, and how the company officials hastily capitulated, exempting him completely from the operation of the new rule—their decision accelerated by an unexpected mathematical problem awaiting the attention of the only man in the organization who could do anything with it.

Wide recognition in his own profession and a wondering admiration for his ability among the laity now entered into Dr. Steinmetz's career. But he remained, as always, a simple, democratic personage, speaking quietly in his curiously thin falsetto voice, smiling easily and winsomely, and seeking ever the happy-go-lucky society of congenial souls.

Eternally a social individual, with much hidden, unsuspected sentiment lying beneath the surface, Steinmetz was wont to become much attached to people and places. Within the first five years of his residence in America, he became a full-fledged naturalized American, developed American habits and whims, and Americanized his name by changing "Carl" to "Charles" and substituting for his two middle names the more individual, more cher-

A RECREATION THAT STEINMETZ LOVED
In company with his adopted grandsons, Billy Hayden (on the left) and Joe Hayden, Steinmetz went canoeing up and down the Mohawk River every summer

ished college nickname, "Proteus," which he came more than ever to merit.

He always hated to shift his home into new and unfamiliar surroundings. Hence it was with solid satisfaction that he began to realize that his residence in Schenectady would undoubtedly be permanent. He thereupon began to feel at home there and to give full play to his odd, semi-bohemian tastes and his curious hobbies.

Two or three bosom companions had come over with him from Lynn, chief among whom was Ernst J. Berg. Steinmetz and he set up a domestic establishment of their own in Schenectady, in a rented house on Washington Street. Within a year they moved to another place on Liberty Street and were joined by Mr. Berg's brother, Eskil Berg.

Loosely united in a delightfully informal domicile, conducted on strictly communal lines, these three quickly earned a reputation for themselves as jovial, merry, boyish personalities. They combined scientific pursuits with bachelor housekeeping and soon added a small-sized menagerie of queer pets, most of which were acquisitions of Steinmetz and E. J. Berg.

These numbered, at various times, raccoons, supposedly tame; an alligator or two, the special pets of Steinmetz; owls, squirrels, monkeys, and a pair of crows, with which Steinmetz had made friends in some mysterious manner. He called them John and Mary, professed to be able to converse with them and attracted the attention of the entire neighborhood by his antics with them in the yard. They certainly came to know the little man with the ready smile and gentle, serene eyes; and one of them was accustomed to perch on the window sill of Steinmetz's room to peer at him.

It was here also that Steinmetz first began to collect desert plants, particularly cacti. The Liberty Street property had a small, octagonal house with large windows, and here Steinmetz placed his horticultural display. In a stable out in the yard he set up an electrical and chemical laboratory on a small scale, which was later nearly destroyed by fire.

Steinmetz had become enamored of the Mohawk River, which he and Berg explored one Sunday afternoon, soon after their arrival in Schenectady. During that excursion Steinmetz had discovered a placid, picturesque tributary of the river, known locally as Viele's Creek. And on one of the sloping, tree-screened banks of that stream he erected, a year or two later, a little one-room camp, supported on the steep riverside by timber braces which looked none too stout.

Almost the first use Steinmetz made of this rustic refuge was to hold a housewarming, to which he invited all the young General Electric engineers whom he knew. He also had a band come out from Schenectady, and placed the musicians on that somewhat perilous side of the room directly over those slender supports. The timbers held fast, and Steinmetz thereupon decided that since the band had survived the structure was firm enough to use for any ordinary camp purpose.

The Century Company, N. Y.

STEINMETZ AND MARCONI
From a photograph taken in Schenectady in 1922


Courtesy General Electric Company

THE LIGHTNING MAKER ENTERTAINS

This is the only photograph ever taken of visitors viewing the work of the lightning generator. Dr. Steinmetz is shown seated with Thomas A. Edison. J. Leroy Hayden, adopted son of Steinmetz, is explaining the apparatus

The camp had been in existence only two or three years when Steinmetz one spring made the casual acquaintance of a young engineer named Joseph Leroy Hayden. He was a companionable chap and willingly assisted Steinmetz at his week-end parties. This helping-hand attitude, combined with Hayden's cheerful, good-natured disposition, endeared him to the odd little man of genius. Thus it was, when the trio of young engineers on Liberty Street broke up, in 1900, that Steinmetz made a constant companion of "Roy" Hayden.

Then, in 1901, he began to build himself a house on Wendell Avenue, Schenectady—a roomy mansion, and a fine large conservatory for his extensive collection of cacti, orchids, and ferns. Even before he had his house ready there was a shelter for his plants, and a private laboratory on the property, built for him by the General Electric Company.

His inseparable chum in these days was Roy Hayden, who liked him in all his absorbed scientific moods and peculiar social idiosyncrasies. Indeed, the one really pathetic period of Steinmetz's life came when, simultaneously, his big house was finished and his boon comrade got married and left him.

The Century Company, N. Y.

EDISON VIEWS THE LIGHTNING GENERATOR

Dr. Steinmetz and his close friend Thomas A. Edison standing in front of the Steinmetz lightning generator. During a visit to Schenectady, Edison inspected the famous Steinmetz apparatus and saw it work

Courtesy General Electric Company

IN HIS LABORATORY

The scientist is here shown examining the fragments of a tree limb just after a "synthetic" lightning bolt was discharged

He had a comfortable dwelling and faced the prospect of living in it absolutely alone!

He could stand this only a week or two. Then with naïve simplicity he sought out young Hayden and proposed that he and his bride make their home with him in the new house. The suggestion had a whimsical appeal about it that led Mr. and Mrs. Hayden to agree. And from that time forward Steinmetz considered them as his adopted household. He became daddy to them both, and eventually granddaddy to their three children, Joe, Marjorie, and Billy. Some years later he legally adopted Hayden as his son.

The zest of acquiring his own home, and adopting a bridal couple to live in it with him, was shared by the fascination of a new scientific enterprise, the invention of an arc lamp. Steinmetz, after much experimenting in his private laboratory, brought out, in 1901, a luminous arc light known as the "magnetite arc"—brilliant and of high efficiency. A dozen years later hundreds of thousands of these lights were in use for street illumination in communities throughout the nation.

Quickly following this came the appointment of Dr. Steinmetz as professor of electrical engineering at Union College. It was a new experience for this remarkable scientific genius, whom men had begun to call a "wizard," and whom the General Electric Company had just made the head of its newly established consulting engineering department. With the utmost enthusiasm Dr. Steinmetz entered upon his collegiate duties. His lectures were delivered to classes of juniors and seniors. They were wondrous, overwhelming expositions of the great fundamentals of electrical science. They lasted two hours, with a fifteen-minute intermission, and at times, when the doctor's enthusiasm fairly carried him away, the students were quite unable to follow him. They were bewildered, but somehow from it all they obtained a tremendous inspiration for their vocation.

On one occasion, when the strain was a little too much for them, fully half the class did not return to the lecture-room after the intermission. Yet as Dr. Steinmetz called the roll a voice answered "Here!" for every name. As he finished the list Dr. Steinmetz looked around the room, gave his trousers a characteristic hitch, and remarked, with a suspicion of a twinkle:

"Only twenty-five men are here, yet fifty answered to roll call! Remarkable mathematical phenomenon!"

Dr. Steinmetz held his professorship until 1913, when he was succeeded by his old housemate, Ernst J. Berg. Steinmetz was made professor of electrophysics, which required only one or two lectures a year, his engineering activities becoming too absorbing to allow his continuance on the faculty.

He had become a person of much distinction in his profession and to an enlarging circle outside. He had received an honorary degree from Harvard University and a little later another from Union College. He was elected president of the American Institute of Electrical Engineers barely ten years after the memorable meeting at which he presented, in halting English, his renowned papers on the law of hysteresis.

His scientific work had now launched into the third of his three great life investigations—a study of what electrical engineers call "electrical transients," which include especially the pranks of lightning discharges. For several years this work went on quietly; then, one day in the summer of 1920, a lightning bolt struck his little camp on Viele's Creek, and Dr. Steinmetz spent several days studying the freakish damage inflicted by the cloud-born energy.

From information thus gleaned he built, in his laboratory at the General Electric works, an apparatus known as the Steinmetz lightning generator. By means of this generator, in 1922, he actually produced artificial, or laboratory, lightning which wrought destruction, upon a miniature scale, exactly like that caused by the bolt which visited the camp. And soon, while the whole technical and popular world stood astounded, he was busily using his synthetic lightning to test lightning arresters, and

Courtesy General Electric Company

STEINMETZ AND PROFESSOR EINSTEIN
This photograph was taken during Einstein's visit to America in 1921

devise more reliable means of safeguarding great modern electrical systems from the "terror of the skies."

His lightning experiments caused a great sensation to the popular fancy. Newspapers acclaimed him as a "Modern Jove." His name went all over the land as a worker of miracles and a "wizard"—a word, by the way, which he always hated to hear applied to himself. He regarded his laboratory work as merely a logical, carefully planned program of investigation, with good, sound, practical results as its objective.

Dr. Steinmetz studied lightning for fully twenty-five years. No sooner did electrical systems begin to expand, in the early nineties, than he perceived the importance of this field of experiment. But during most of this period his work was unspectacular. It was not until he had advanced farther than most scientists of his day that he proceeded to produce his own lightning, and to produce in ever greater volume, up to the very year he died.

Dr. Steinmetz was a Socialist of the idealistic type, quite pronounced in his views—yet a moderate Socialist when it came to action.

In 1911, when George R. Lunn was elected Socialist mayor of Schenectady, Dr. Steinmetz offered his services to the Lunn administration. The latter promptly appointed him to the Board of Education, which in turn honored him by election to the presidency of the board. Ever a believer in education, particularly by the American method, Dr. Steinmetz threw himself into the cause of better schools and more schools. He did much in this field; then, four years later, he was elected president of the Common Council, under a second Lunn Socialist administration.

For many years thereafter Steinmetz remained on the Board of Education as a member, even after Lunn had ceased to be a Socialist and finally had ceased to be mayor. Moreover, in 1922, Steinmetz was a candidate for state engineer and surveyor of New York State, on a Farmer-Labor ticket; but, despite a really handsome vote, his avowed Socialistic ideals put him far behind the candidates of the so-called major parties.

Through all these active days Dr. Steinmetz lived a quietly domestic life with his adopted family in the big house on Wendell Avenue. His love for children here made itself beautifully evident. He was the close companion and kindly granddaddy of the Hayden youngsters and the well-loved crony of all their small friends. And his strange plants, his queerer pets, and his camp on the creek, which he enlarged from time to time, comprised the sum total of his hobbies and amusements.

His camp was his constant haunt during the pleasant part of the year. He fairly lived at the camp for weeks at a time. His habits while there were so simple and unpretentious as to astonish those who saw him at such times. His invariable costume was a bathing suit and a somewhat faded red sweater, which he never changed, not even if visited by the most dapper or most

International News Reel

STEINMETZ TALKING OVER THE RADIO
Broadcasting an explanation of the method of making "synthetic" lightning

renowned personages. His favorite method of working in the summer was to go out in a little one-man canoe, lay a board across this diminutive craft, on which to place his papers carefully weighted with stones, and spend most of the day busy with electrical problems while the canoe drifted about in the sunshine. In case of rain he worked at a little pine table on the porch of his camp—still wearing the bathing suit.

He traveled occasionally in the course of his professional work. But the longest trip of his life was one of pleasure—and it came just before his death.

It was in the summer of 1923 that the doctor, accompanied by all the Haydens, set out from Schenectady on a tour of the West and the Pacific coast. His progress was a succession of public acclamations and cordial receptions, electrical engineers throughout the West flocking to hear him and to shake his hand. He gave many addresses, read one learned paper at a Pacific coast convention of the American Institute of Electrical Engineers, and returned to his home in Schenectady early in October. But he came back a travel-weary, heart-weakened man, much more worn out than he himself supposed.

For a week he rested under a doctor's care. Then, suddenly and almost without warning, on October 26, 1923, he died, peacefully and painlessly, from dilatation of the heart.

His estate, to the surprise of some, but not those who knew him well, proved remarkably small. Although a well-paid specialist, Dr. Steinmetz did not lay aside much of his income; and he never desired to have remuneration as generous as he might have received. It was due partly to an actual indifference to wealth and partly to a consistent Socialist-born conviction that no one should be paid in money more than he required for his actual comfort.

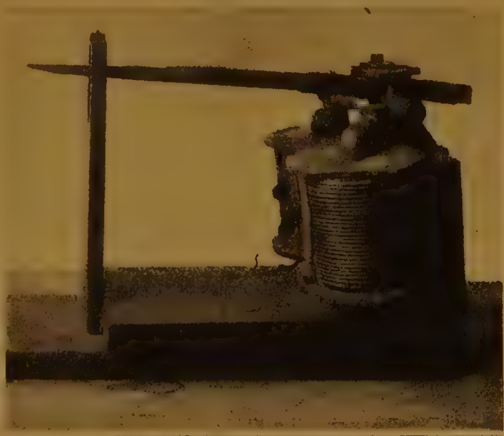
Charles Steinmetz was a strange combination. Seeking to better the world by Socialistic doctrines, he actually did better it by profound mathematical formulæ applied to electrical engineering. An agnostic—some thought even an atheist—in religion, yet he was a member in good standing of a Unitarian society. A dwarf in body, and with none too strong a heart, he nevertheless enjoyed splendid health almost all his life, with sun-tanned limbs and a keen liking for the out-of-doors.

And finally, a mathematical genius unequaled in his time, a scientist, a physicist, a social economist, yet he had a most winsome human disposition, a big affectionate heart, a soft place for dumb animals, a reverence for Mother Nature in all her works, and a delightfully fond regard for happy children.

Loving his fellow men he served them well in the realm of applied science and by individual deeds; and he made the world a better place because he lived in it.

FIRST THINGS IN ELECTRIC INVENTION

BY C. F. TALMAN

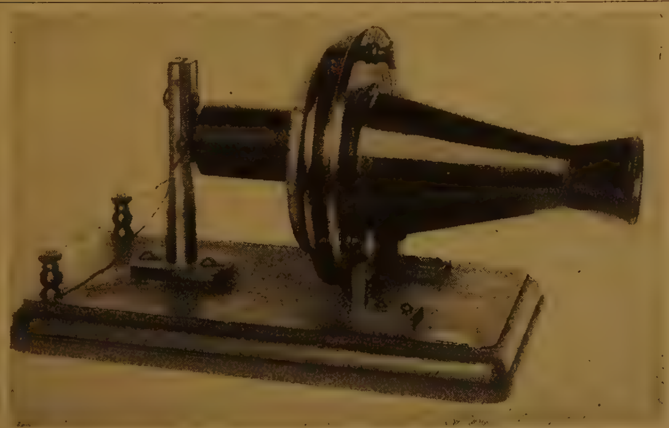


PART OF MORSE'S ORIGINAL RECEIVING APPARATUS

As patented in 1846. Now in the U. S. National Museum, Washington, D. C. The picture does not show the clockwork and moving strip of paper

It takes, as a rule, more than four great inventors to make four great inventions. Dozens of ingenious minds contributed to the invention of the telegraph, the telephone, the dynamo-electric machine, and the incandescent electric lamp. One might say, indeed, that each of these things is still in process of invention, since they are constantly undergoing improvements at the hands of inventors.

Everybody knows that Samuel F. B. Morse invented the electric telegraph. What most people do not know is that, at the time this famous invention was made, at least sixty other systems of electric telegraphy had been given to the world. Messages were sent electrically over wires by Le Sage, of Geneva, in the year 1774, and as far back as 1753 a practical electric telegraph was described by a Scotchman named Charles Marshall. After the Danish physicist Oersted made, in 1819, his ever-memorable discovery that a magnetic needle is deflected when an electric current flows through a wire above or below it, and to the right or the left according to the direction of the current, the possibility of applying this discovery in telegraphy was almost immediately recognized. Several forms of "needle" telegraph based on this principle, including one that printed its messages, were in actual operation in Europe before Morse erected his first experimental line, and a sim-



BELL'S MEMBRANE TELEPHONE TRANSMITTER

This instrument, on exhibition in the U. S. National Museum, was the first of Bell's instruments used for a reciprocal conversation where the stations were miles apart, and not merely in different parts of the same building. The conversation was held October 9, 1876, between Bell in Boston and Watson in Cambridgeport, Mass., a distance of about two miles

In U. S. National Museum

BELL'S IRON BOX TELEPHONE RECEIVER
Part of his historic exhibit at the Centennial Exposition in 1876, which made the telephone known to the world

ple telegraphic alphabet had been introduced in Germany by Gauss and Weber.

Where, then, does Morse come into the story of the telegraph, and what was his title to the honors and distinctions that were heaped upon him, both in his own country and abroad?

Morse enjoyed but little training in either science or mechanics. Like Robert Fulton of steamboat fame, he started out to be an artist, and he studied painting for four years in London after his graduation from Yale in 1811. He was a successful portrait painter long before he became an inventor. It was during his homeward voyage, in 1832, after a second sojourn in Europe, that a chance conversation on shipboard turned his thoughts toward the subject of telegraphy.

The story of his heroic struggles and of his final triumph when, in the year 1844, the historic message "What hath God wrought?" was flashed over the wire from Washington to Baltimore has often been told. Too often the story ignores the indispensable aid he received from his associates—Professor Gale, of New York University, who improved the batteries used with the telegraph and gave valuable scientific advice, and Alfred Vail, who supplied the mechanical skill that Morse lacked, and who was, it is said, the principal author of the "Morse" alphabet of dots and dashes.

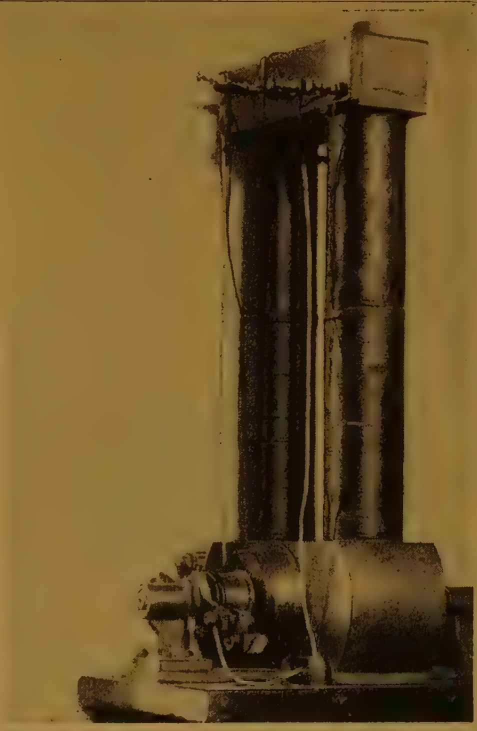
Though so much beholden to others, Morse fully deserves his niche in the Temple of Fame. He did not produce the first electric telegraph, but he produced a far better one than any previously known. The superiority of his invention depended upon his original idea of using a relatively feeble current sent over a long wire to bring into play a device known as a "relay," which is worked by a strong local current. For his relay Morse used an electromagnet—an instrument which had been invented by the Englishman Sturgeon and greatly improved by the American Joseph Henry. In fact, Henry himself had, as early as 1831, employed this same instrument to ring a bell under the impulse of an electric current sent over a mile of wire: one of the many partial anticipations of Morse's great achievement.

Alexander Graham Bell's relation to the telephone differs decidedly from Morse's to the telegraph. The telephone as we know it to-day is due to many able inventors, but Bell was the pioneer of them all, the first person that ever

transmitted speech by wire. The priority of Bell's invention was established by the long-drawn-out lawsuits that followed the first commercial exploitation of his invention. Bell was a student of acoustics, an elocutionist of note, and a teacher of deaf-mutes by a system of "visible speech" invented by his father. He was born and educated in Scotland, but was living in Boston when he made his great invention. Though he had long cherished vague plans for a speaking telephone, he was actually trying to invent something else; viz., a "harmonic telegraph," by which it would be possible to send several telegraph messages at the same time over one wire. On June 2, 1875, he and his assistant, Thomas A. Watson, were experimenting with one of the installations devised for this purpose. They were working in separate rooms, trying to tune their sending and receiving instruments so that three messages might be transmitted at once without interference. Vibrating springs, forming the armatures of magnets, were used at both ends of the line. Watson plucked one of these, and Bell was astonished to hear the twanging sound perfectly reproduced. From this accident came the telephone, for Bell knew enough about acoustics to realize that other complex sounds, including human speech, could be transmitted in the same manner. Many months were spent working out the details of the invention, and the first practical telephone was exhibited at the Centennial Exposition, in 1876. Here it came near being ignored until it attracted the attention of two foreign visitors—Dom Pedro, Emperor of Brazil, and Sir William Thomson, afterward Lord Kelvin—and then Bell suddenly found himself famous. The patent which Bell secured on the telephone in 1876 has been described as "the most valuable single patent ever granted."

The word "dynamo," though seldom used nowadays by electricians, is still popularly applied to a device for converting mechanical energy into electrical energy by utilizing the principle of electromagnetic induction. In technical language such machines are called "dynamo-electric generators" or simply "generators." The wonderful dynamos of to-day, which supply us on a vast scale with light and power, were developed by slow stages from a simple machine invented in 1831 by Michael Faraday. It consisted of a copper disk revolved between the poles of an ordinary horseshoe magnet. The motion of the disk produced a current which was

EDISON'S INCANDESCENT LAMP AND SOCKET, 1880
The earliest lamp having a screw socket. The Edison lamps previous to 1880 had no socket, or one permanently attached to the bulb



EDISON'S DYNAMO, 1879

Used on the steamship *Columbia* as a part of the first commercial installation of the Edison incandescent lighting system. It is now preserved, with other "first models," in the U. S. National Museum

communicated to an external circuit through two brushes: one bearing on the border of the disk, and the other on its shaft. Later, rotating coils were substituted for the disk, leading up to the elaborately wound armatures of modern machines. The use of electromagnets instead of permanent magnets was patented by Wheatstone and Cooke in 1845. The next great step was to use current generated by the dynamo itself to "excite" the magnet. This invention was made by Hjorth in 1855. Further improvements were made by Pacinotti, Gramme, Siemens, Edison, Tesla, and many others.

At the Vienna Industrial Exhibition of 1873 an absent-minded workman one day connected the wires of a dynamo in operation to one that was idle. To his surprise the armature of the latter began to spin around. Thus was made the momentous discovery that the machine designed to change mechanical power into electricity can also be used to change electricity into mechanical power, or that a dynamo is also a *motor*.

The process of making a wire or filament glow by passing an electric current through it was known in the early part of the nineteenth century, and many experimental "incandescent" lamps operating on this principle were produced in Europe and America before the year 1878, when Thomas A. Edison began experiments to develop one that would be commercially practical. Electric lighting was then already in common use, but the lamps were the "arc" variety, in which the light is produced by a flame crossing the air gap between two electrodes. These were good for street lighting but too powerful for ordinary indoor use. Edison's experiments were made in his laboratories at Menlo Park, New Jersey, and in October, 1879, his first successful lamp was finished. Its distinctive features were a filament of high resistance, operating in a high vacuum, maintained by a one-piece glass globe, all joints being welded by the fusion of the glass. The first commercial lamps, used in 1880, had filaments of carbonized paper, for which carbonized bamboo was substituted the same year. More efficient and durable carbon filaments were introduced a few years later.

"THE CROWNING OF LABOR"

THE JOHN W. ALEXANDER MURAL PAINTINGS IN THE CARNEGIE INSTITUTE, PITTSBURGH

WITH DESCRIPTIVE TEXT BY MRS. JOHN W. ALEXANDER

THE APOTHEOSIS OF PITTSBURGH

Rising out of smoke and steam emerges a mailed figure typifying Pittsburgh—a knight in steel armor, suggesting the strength and power of the city.

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"THE CROWNING OF LABOR"

EARLY in the spring of 1906, a letter from Mr. Frew, who was then president of the Carnegie Institute in Pittsburgh, came to John Alexander asking him to meet the board of directors, to discuss the decorating of the entrance hall of the Institute. John W. Beatty, the art director, was Mr. Alexander's close friend. It was he who originated the international art exhibitions which have made the Carnegie Institute famous. Alexander was living in Paris at the time these exhibitions were inaugurated, and Mr. Beatty had often turned to him for introductions and help.

Alexander was a native of Allegheny City, Pittsburgh's largest suburb, and, although he never lived there after his early youth, he did not lose touch with his friends and their interests.

When Mr. Alexander received the summons to Pittsburgh he supposed his presence was desired as a consultant in regard to decorating the hall of the Institute. There was no intimation that any part of this important work was to be offered to him. So far his only contribution to mural painting was the series of lunettes in the Congressional Library, "The Evolution of the Book." Before there was time for any preliminary discussion, the commission was offered to Alexander to decorate the entire hall at a price and under conditions that had been settled by the board before his arrival. Of course he was overjoyed at this evidence of recognition by his native city. He returned to New York almost immediately and set to work to plan his subject and composition.

His custom in painting was not to make a drawing on canvas, but to work directly from his model. Sometimes he would put in a few charcoal lines to indicate the placing of objects and the composition of his pictures, and still less often he made small pencil sketches, so brief that they were interesting only to him and to those who were accustomed to watch him work.

For the Pittsburgh decorations the only studies left by him were two water-color sketches of the panels over the main staircase. These were mere notes, although in color. One of them he gave to Mr. Frew and one is in the possession of his family.

The subject finally selected for the decorations was "The Crowning of Labor." The decorations as he left them consist of a frieze of fifteen panels surrounding the entrance floor; a series of very large panels at the top of the main staircase, which are treated as a unified composition running back of the pilasters; twelve panels grouped about the second-story stair well, and a group of panels at either side of the second-story gallery.

The twenty-one panels designed for the third story were not far enough advanced at his death to place, and these walls have been left with only a coat of toned paint to keep

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MAIN HALL, CARNEGIE INSTITUTE, PITTSBURGH, SHOWING THE ALEXANDER MURALS

them from being out of key with the decorations of the lower stories. It is intended that they shall show the results made possible by industry and the various arts and sciences represented in the work of the Carnegie Institute and Library.

The panels of the frieze of the first floor show the energy and force of labor. They are filled with toiling figures seen in and out of smoke and steam from the furnaces, the immense harnessed energy of which is directed by labor into various useful channels.

From these panels the smoke and steam rise up into the larger panels at the head of the main staircase, where emerges a mailed figure typifying Pittsburgh.

Pittsburgh was depicted as a knight in steel armor in order to suggest the strength and power of the city. Labor having reached its highest expression, the city is crowned and heralded by hosts of winged figures blending with the clouds of vapor.

Winged figures appear on all sides of the second floor except in the alcoves, where the panels again represent energy and constructive forces, but differ from the frieze of the first floor, for here we find depicted high buildings in process of erection, heavy trains of cars, boats on the rivers, blast furnaces, and the hills which are so much a part of Pittsburgh.

At each end of these alcoves high narrow panels, representing men at work against the sky as if at a great elevation, connect the frieze with the larger panels of the second floor.

About the third-floor stairway is a series of twelve panels containing nearly four hundred

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figures which represent the ceaseless, onward movement of the American people.

The studio in which the artist was working when the commission for the Pittsburgh decorations came to him was not large enough for this new work, so he set about looking for one that could conveniently house the great spread of canvas of the larger panels. It was also important for him to reserve his old studio for his portrait painting, which went on at intervals during all the years of his work on the decorations. He turned to this change in the direction of his work as a rest, and when the physical side of painting the decorations overtaxed his strength he would close the larger studio and spend weeks painting portraits in the smaller one.

He found an admirable workshop in Carnegie Hall in a large studio sublet to him by his friend Charles Dana Gibson, and there he painted all the large panels placed at the top of the main staircase and the larger panels of the side walls of this story. He tried, at first, to get assistance, for the mere spreading over of paint on these immense areas of canvas entailed great expenditure of energy. This attempt was a failure because he worked entirely with his left hand, and the work of his helpers became immediately confusing in technic.

At Seabright, New Jersey, in a large studio originally built by him, most of the remaining panels were completed during four summers of uninterrupted work. In the procession of people forming the composition of the upper staircase panels he used all types. Friends and many models brought in from the village of Seabright and its vicinity were

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pressed into service to make up variety.

Alexander used canvas specially woven for this work. His colors were prepared in very large tubes for his convenience. He was greatly assisted by his studio man, Charles Behrens, who had come to him as a young boy from the Avenue A Boys Club, and who was so accustomed to assist that he could feed Alexander's palette and so relieve him of constantly stopping his work to renew his colors.

Two large movable scaffold ladders were made, one for the artist and one for his models, and Behrens would sometimes move these about, under direction, and save the painter and model from a constant descending and climbing of their steep steps.

The actual laying on of the paint was exceedingly taxing to a man of Alexander's frail physique, and after the placing of the decorations now in the Institute he became less and less able to go on with the third-floor series. At his death they were so little advanced that it was not possible to place them even as fragments, and the method of working directly on the canvas left no studies from which to have them completed.

The Carnegie decorations were attached to the walls with tons of white lead, which really makes them part of the wall but prevents the danger of cracks and other injuries.

One of the things that most delighted Mr. Alexander was the effect of the murals upon the mill people who came to see them. As a child he had played about the manufacturing districts of his native town and had a first-hand knowledge of the somber side of the great iron and steel works. The object of his decorations was to illustrate how all the toil and fatigue of the workers produces, in the end, the beauty and inspiration of life.

That this ideal was understood and appreciated came to him from many sources. One man wrote that he had never been happy in his work until after this thought had been made plain to him by its illustration on the walls of the Institute. Now that he knew he was contributing his mite to the ennobling of the lives of others he felt renewed courage to go on with what had formerly seemed only bleak drudgery.

There is no doubt that the strain of this decorative work contributed to hasten Alexander's death. He had always been an indefatigable worker from the time he first came to New York as a boy with fifty dollars in his pocket as his only source of capital. At the height of his success a brief illness ended his life. He not only contributed largely to painting but wore himself out in service for the fostering of art in America.

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TWO PANELS REPRESENTING STEEL CONSTRUCTION

THE STEEL MILLS

THE WATER FRONT

Courtesy the owners, The Wells Construction Co., New York

"THE SPAN," By Fred Dana Marsh

SPIDER WEBS OF STEEL

BY STEPHEN ELMER SLOCUM, PH. D.

THE spider that spins its web across your window is working with an age-old instinct to secure the means of existence, and yet its gossamer lacework glistening with dew in the morning sunlight is nevertheless a thing of beauty, because in nature beauty and utility are inseparable elements. Like the spider, the engineer spins a web of steel—a web across a stream to serve a useful purpose. The graceful symmetry of his handiwork reveals an intrinsic beauty of line and form, which is the professed aim of art, with the added distinction of service to his fellow men.

In America there are two typical forms in which engineering genius has found artistic expression; namely, the skyscraper and the long-span steel bridge, especially the suspension type. When we analyze the impression created by the skilled technic of the bridge builder or the architect we find that it rests on conformity to natural law. The fundamental principle of æsthetics is symmetry. The symmetrical order in which the spans of a bridge are arranged gives the impression of clearness of principle, and leaves no question in the mind as to the suitability of the structure to the purpose for which it is intended.

The two great principles of engineering design are that a structure shall harmonize with its environment, and also that its form shall never disguise its purpose, but rather impress the mind with visible strength and a sense of proper adaptation to its purpose.

The development of steel as a structural material, which has made the skyscraper a distinguishing feature of American engineering skill, has been accompanied by an equally characteristic development in bridge construction. American bridge design is not only a triumph of technical skill but of artistic expression as well. The illustrations which accompany this article exemplify the superb dignity and simplicity of typical examples of the suspension bridge.

The simplest curve in nature is that formed by a hanging cord. This graceful curve is called a "catenary," and it forms the characteristic feature of a suspension bridge. When a cord supports a uniform horizontal load, however, as in the case of the roadway supported by the cables of a suspension bridge, the curve changes its shape somewhat and approximates a parabola. This slight difference in shape, although it is carefully taken into account by the bridge designer, is not sufficient to be apparent to the eye. The distinguishing feature of a suspension bridge is therefore the graceful, natural curve of the catenary.

Suspension bridges in the form of simple rope or chain cables spanning narrow streams are very ancient, no doubt in imitation of the simple grapevine bridges that have spanned rustic streams from prehistoric times.

The first suspension bridge constructed on scientific principles seems to have been one

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FOOTPATHS ON THE BEAR MOUNTAIN BRIDGE

This photograph, taken from the west shore of the Hudson, shows the Bear Mountain bridge in course of construction. Two giddy footpaths have been thrown across the Hudson River, each supported by two steel cables two and one-quarter inches in diameter. The footpaths are nine feet wide and hang one hundred and eighty feet above the water at the lowest point. They are the paths along which the construction work of the bridge is conducted

CLOSE-UP OF CABLE-SPINNING WHEEL

Note the small size of the wire, also the two skeins of wire passing over the sheaves of spools at either side, which when filled will be bound together into one of the strands forming the main cables. This picture was taken during the construction work on the Delaware River bridge, Philadelphia-Camden, in November, 1924

built in 1806-8 by the famous bridge engineer Theodore Burr. In this historic bridge the cables were built up of wooden planks, and for many years the picturesque and notable structure spanned the Mohawk at Schenectady. An illustrated description of this pioneer bridge appears elsewhere in this issue.

Suspension bridges with cables formed of flat iron links joined together by pins were developed in England between 1814 and 1830, but the first suspension bridge of the modern type, using steel wire cables, seems to have been the old aqueduct bridge across the Lackawaxen River at High Falls, New York, built by John A. Roebling in 1844 as an aqueduct for the Pennsylvania Canal. Roebling was the inventor of wire rope, and began its manufacture in 1840 on his farm in western Pennsylvania. Its first use in bridge construction was at High Falls.

The most spectacular achievement in the early history of suspension bridges was the construction of the railway bridge over Niagara Gorge, spanning the foaming rapids. This was begun in 1852, and all the world in that day knew how Roebling flew a kite across the gorge, and with the first line from it built up his cables. The first train passed over the bridge in 1855, and for half a century it carried an increasingly heavy traffic until it was replaced by the present bridge.

In 1846, before the Niagara bridge was built, a project had been set on foot to build a suspension bridge across the Ohio between Cincinnati and Covington. This was bitterly opposed by the steamboat faction, who staved off the project until 1856, when work was finally begun. The panic of 1857 and the Civil War further delayed the project until 1863, but finally, on Easter Day, 1867, the second great bridge of the suspension type was opened.

These two notable bridges paved the way for the construction of the first New York bridge, still known as the Brooklyn Bridge. This was the crowning achievement of Roebling's life, but he was not destined to see it completed. While laying out the piers and approaches to the bridge and before the

work of construction was actually started, an accident in docking a ferryboat crushed his foot and brought on tetanus, from which he died. The entire work of construction therefore devolved on his son, Col. Washington Roebling, and for thirteen years he labored at this Herculean task, until success finally rewarded his efforts.

From an artistic standpoint, this is probably the most successful bridge ever constructed. The massive masonry towers with their imposing Gothic portals give a satisfying sense of dignity and solidity, while the graceful curve of the main cables, with the lacy network of diagonal supports, combines with the cambered roadway to produce an artistic result unsurpassed in bridge construction and typical of the best American precedents.

This project also met with great opposition, but the unusually severe winter of 1866-7, when a business man taking a train at Albany was able to reach New York before one who left his home in Brooklyn at the same hour, created an imperative demand for a bridge across the East River, and in 1867 the initial charter was granted. Work on the project was begun in 1870, but it was not until six and a half years later that the master mechanic crossed for the first time on the slender aërial from which the cables were to be built. In a "bosun's chair" he shot out from the top of the Brooklyn tower, down the long slope of the aërial and up the incline to the New York tower, while bands played, tugboat and steamer whistles shrieked, cannon roared, the crowd cheered, and dogs barked. Seven years later, in 1883, the great bridge was opened with suitable ceremonies and became the first link in the development of Greater New York.

In these pioneer bridges the principle of design was a much simpler proposition than the method of construction. As suspension bridges multiplied, improved methods of construction were devised, but, for all that, it is curious to note how closely the modern bridge builder still follows the methods of the

CABLE-SPINNING WHEEL ON DELAWARE RIVER BRIDGE

The wheel is about to start on its journey across the river. This is the ingenious substitute for the web-spinning apparatus of the spider, which the engineer imitates in building up the cables of a suspension bridge

AËRIAL FOOTBRIDGES, DELAWARE RIVER BRIDGE

These paths connect the towers and abutments, and the supports for the trolleys on which the cable-spinning wheel travels backward and forward thousands of times in its long journey. Nearly thirteen thousand miles are covered in the task of spinning each of the main cables

tiny spider in fabricating his great steel structure weighing many thousands of tons.

From the beginning of time the spider and the bee have wrought in accordance with a fixed plan, with a fine disregard for the mandates of evolution. The spider of to-day spins a web of just the same pattern as that which King Solomon observed in his palace and thought worthy of mention in the thirtieth chapter of Proverbs; and the honeycomb we know is of the same pattern as that which Samson took from the carcass of the lion. The spider now, as then, fixes the end of his tiny cable and launches forth across the opening he plans to bridge. Back and forth the gossamer threads are spun, bracing the network in every direction, and finally tying the whole together with a given surface of comb in accordance with well-known mathematical principles.

It lends a deeper interest to the study of great modern bridges to note their resemblance to such instinctive natural creations. The first step, of course, is the erection of the great towers of masonry or steel which are characteristic features of a suspension bridge.

This is followed by the erection of an aërial footbridge between the towers, from which to proceed with the construction of the cables. For this purpose traffic on the river is halted while a scow carrying a great drum of wire rope is towed across the river, paying out the rope as it crosses. This rope is then hoisted from the river bottom and suspended from the tops of the towers, forming the first connecting link between them. On these wire rope aërials, wooden footbridges are built, and braced with wires to keep them from swaying in almost the exact manner in which a spider braces its web. This is shown in the accompanying pictures of the Delaware River bridge.

On these footbridges are erected supports for an overhead trolley on which the cable-spinning wheel travels back and forth in the seemingly endless task of spinning the giant

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LINKING UP TWO CITIES: PHILADELPHIA-CAMDEN

A close-up picture of the temporary wooden footpaths slung on steel cables at a dizzy height above the Delaware River

Wide World Photos

ASSEMBLING THE CABLES

This picture, taken in October, 1924, shows the bridge builders engaged in the dangerous task of assembling seven thousand five hundred miles of wire into the cables which support the bridge across the Hudson from Bear Mountain to Peekskill, New York. The completed cables are two thousand six hundred feet long and eighteen inches thick

© Keystone View Co.

INSPECTING THE CABLE OF THE BROOKLYN BRIDGE

The discovery some time ago of a weakened span in the oldest of the New York-to-Brooklyn bridges has increased the care with which the daily inspection is made

cable, a wire at a time. Here the genius and ingenuity of the engineer make their appearance. The tiny spider which so many have idly watched from the beginning of time has now become a wheel, actually called a "spider" by the workmen, traveling back and forth across the span thousands of times as it spins the thin steel thread. Each wire is continuous like the yarns of a skein, carefully adjusted to a uniform tension, and lying parallel and separate, with no twist as in a wire rope. These separate wires are then bound together into strands and finally the strands clamped together into the massive cables from which is hung the entire weight of the bridge.

When the main cables are completed, the work of attaching the vertical or diagonal suspending cables which support the roadway is begun. The latter is not the simple thing it might seem, but a shallow truss, designed as a stiff beam to give the bridge stability and distribute the load to the network of supporting cables. Here the bridge builder meets with the great difficulty of providing for the expansion and contraction of the main cables and verticals due to change of temperature.

With the exception of this stiffening truss, a suspension bridge has all the natural grace and airy lightness of a giant spider web swinging between two great trees, and art in bridge building consists in subordinating the truss to the rest of the structure and emphasizing the towers to bring out by contrast the lacy outline which delights the eye. The artistic success of the old Brooklyn Bridge is due to the unusually successful combination of these three elements of construction. Comparison of the types shown in the accompanying illustrations will bring out clearly the relative merits of various suspension bridges in this country, and exemplify the notable success that American engineers have attained in developing this characteristically American type of structure.

These bridges, taken collectively, exhibit the highest development of engineering skill as well as artistic craftmanship, and constitute an inspiring example of what may be accomplished by imagination and perseverance in overcoming natural obstacles.

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THE BROOKLYN BRIDGE, BUILT 1870-1883

The first great structure to span the East River at New York. Each cable is composed of nineteen strands, and each strand consists of two hundred and seventy-eight separate wires, making a skein a million feet long in each cable. Span, 1,595½ feet; clear height at center, 135 feet. The original cost estimate of this bridge was five million dollars, but during the thirteen years required for its construction this increased to fifteen and a half million dollars—quite a sizable sum fifty years ago

HUMAN SPIDERS PAINTING THE BROOKLYN BRIDGE

These men take a big risk daily in a most necessary work—covering the steel fibers of the Brooklyn Bridge with protective paint

THE FINAL LINK IN THE QUEENSBORO BRIDGE ACROSS THE EAST RIVER AT NEW YORK

THE COMPLETED QUEENSBORO BRIDGE

Connecting Manhattan Island and Long Island. A notable example of the American builders' genius in cantilever bridge construction

THE MANHATTAN BRIDGE, EAST RIVER, NEW YORK, IN COURSE OF CONSTRUCTION

THE COMPLETED MANHATTAN BRIDGE

An achievement of great beauty, unsurpassed in bridge-building art

THE WILLIAMSBURG BRIDGE, EAST RIVER, NEW YORK

In which technic predominates over artistic effect

Wide World Photos

BEAR MOUNTAIN BRIDGE COMPLETED

The world's first automobile bridge—built for motor traffic. The main span is 1,632 feet—including approaches, 2,252 feet. This structure will accommodate four lanes of traffic—two east and two west. The bridge was designed by Joseph Baird of New York and was built by private capital. Automobiles have to pay toll

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PLAN OF PROPOSED BRIDGE ACROSS GOLDEN GATE, SAN FRANCISCO

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PROPOSED HUDSON RIVER BRIDGE

Pictures of two great "futures" in bridge building. The Golden Gate, to cost over $17,000,000, is to swing 200 feet above water and have a 6,700-foot span, giving 90,000 persons direct transit. The proposed Hudson River bridge, between Manhattan and Weehawken, New Jersey, will be a giant structure, accommodating sixteen lines of vehicles and twelve railroad lines. The towers will be 780 feet high and the central span will be 3,200 feet long, and high enough above the river to permit passage of any vessel

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BEAR MOUNTAIN BRIDGE OFFICIALLY OPENED

Picture showing the first cars to cross the bridge on Thanksgiving Day, 1924. They contained officials of the project and guests. Mrs. E. H. Harriman unveiled the tablet dedicating the bridge

BEN FRANKLIN AND THE KITE

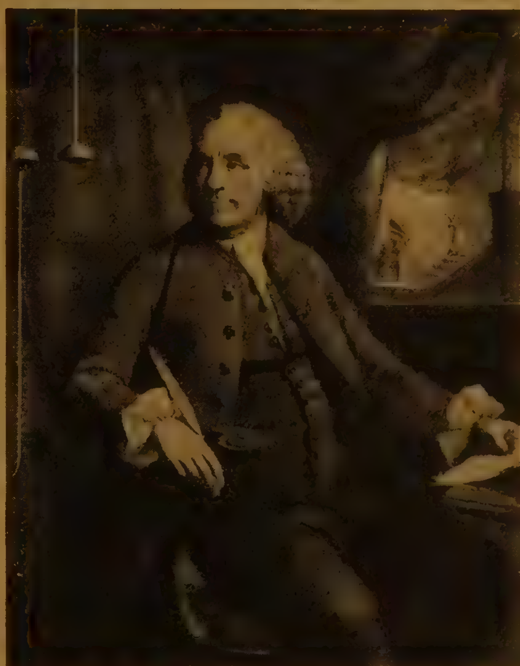
BY RICHARD DEAN

The boldest question ever put to Nature, and the most sublime faith in the truth of a great idea ever exhibited are to be found in the epoch-making experiment of Ben Franklin, who flew his kite into a thundercloud, drew the lightning from the heavens, and established for all time the identity of lightning with the electricity got from the Leyden jar.

Early in his experimenting Franklin had made the highly important discovery that metallic points serve to draw off the electric fire from a charged body and quietly dissipate it without the usual brilliant flash of light and sharp report.

Could it be possible that the clouds in ascending from the sea carried with them vast quantities of electricity which some tall tree, some lofty church spire, or lonely mountain peak drew forth in the vivid lightning flashes of the celestial artillery? Was this mighty crash of the warring forces of earth and sky, this fury and turmoil of the eternal battle of the clouds, but the simple phenomena of the Leyden jar magnified to the proportions of true celestial grandeur?

Franklin determined to put these questions to Nature herself. Therefore, in a letter to the Royal Society, he proposed that a sort of sentry box be placed on the top of some tall tower, the box to contain an insulating stool from which should extend into the clouds above an iron rod thirty or forty feet in length. It was his theory that a man standing upon this stool during a thunderstorm would be able to draw sparks from the iron rod, just as he could from a charged Leyden jar.



A RARE PORTRAIT OF FRANKLIN

Painted by M. Camberlin, an English artist. This picture is reproduced from an engraved copy in the possession of the Metropolitan Museum of Art

Because of the refusal of the Royal Society to consider the project, Franklin's letter was first published in France, where it immediately became the all-absorbing topic of interest at the king's court and in scientific circles. Two Frenchmen, D'Alibard and DeLor, at once put the experiment to the test. In the garden of the former a pointed iron rod fifty feet in height was erected and at the approach of the first thunderstorm Franklin's predictions were completely verified. But, since this rod did not actually penetrate the clouds, Franklin did not consider his theory completely proved. Therefore, in the absence of any tall steeple in his native city, he determined to fly a kite into the very storm clouds themselves and obtain absolute proof.

To the top of his kite, consisting of "a small cross of two light strips of cedar," over which was stretched a silk handkerchief, he attached a sharp-pointed wire about a foot long. At the end of the hemp string he tied a door key and to the key a length of silk ribbon. Grasping the silk ribbon in his hand and standing under cover, he allowed his kite to ascend into the storm clouds. Then presently, as the hemp string became wet, the loose filaments upon it began to "stand out everywhere," and presenting his knuckle to the key he drew the familiar electric spark. He was also able to charge a Leyden jar with the lightning drawn from the clouds as readily as he could with an electric machine, and with it he performed all the usual experiments.

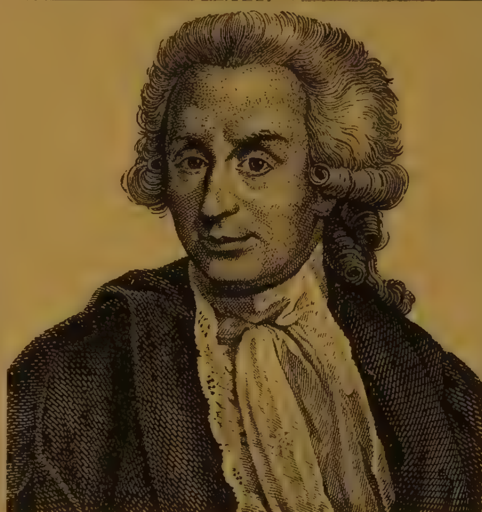
With the application of this great discovery in his invention of the lightning rod Franklin made the first practical electrical device.

GALVANI AND THE FROG'S LEGS

BY FLOYD L. DARROW

In the year 1791 Luigi Galvani, a professor of anatomy at the University of Bologna, Italy, made a discovery that placed his name high in the records of electrical achievement and introduced new words—galvanic, galvanized, galvanism—into the language.

Although the famous experiment was undoubtedly an accident, yet it is true that for years Galvani had been deeply interested in the effects of static electricity upon the nerves and muscles of the human body. One day in his laboratory he placed a dissected frog on a table near his electrical machine. Presently an assistant touched the nerves of the frog's thigh lightly with the point of a knife and immediately the muscles were thrown into vigorous contraction and began to twitch violently. Amazed at the unexpected result, Galvani began a thorough investigation of the circumstances surrounding this peculiar effect. It was found that the twitching occurred only at the instant when a spark was drawn from the electric machine. "Strong contractions took place in every muscle of the limb, and at the very moment when the sparks appeared."



LUIGI GALVANI, 1737-1798

His investigations of the muscular action of frogs when in contact with metals led to the discovery of galvanic, or voltaic, electricity

Galvani next determined to discover whether lightning would have similar effects. Although mindful of the danger attending such experiments, he erected a metallic conductor on the highest portion of his house and carried it to his laboratory below. At the approach of a thunderstorm Galvani suspended on the wire a dissected frog. To the feet of the frog he attached a second wire, which he grounded by allowing it to slip into a near-by well. In the words of Galvani himself: "The results came about as we wished. As often as the lightning broke forth, the muscles were thrown into repeated violent convulsions, so that always, as the lightning lightened the sky, the muscle contractions and movements preceded the thunder and, as it were, announced its coming. It was best, however, when the lightning was strong."

Galvani continued to experiment with frogs' legs for a number of years. In his efforts to learn the effects of "the daily quiet electricity of the atmosphere" he hung several frogs from an iron railing by means of brass hooks passing through their spinal cords. After several days of fruitless waiting, he endeavored to reproduce the twitching of the muscles by pressing the brass hooks against the iron railing. Immediately the muscles responded, as they had previously done with the discharge from the electrical machine and the lightning flash. Evidently electricity from some source was again present. Without knowing it, Galvani had brought about the conditions necessary for an electric cell and a current had flowed through the nerves of the frog. The saline juices of the frog's legs, producing unequal chemical action upon the iron and the brass at the point of contact, had generated electricity. For the first time in history direct observation had been made of the production of an electric current and, crude as the mechanism was and though totally misunderstood, great results were to flow from this discovery.

Curiously enough, Galvani invented a theory of "animal electricity" to account for the effects of his experiments and never appreciated the true significance of his great discovery.

He wrought more wisely than he knew; and future generations of scientists reaped the benefit of his early experiments. His work inspired his fellow countryman Alessandro Volta to make one of the great basic inventions in electrical science, the voltaic battery, which opened up a new era in electrical progress.

WHAT IS A METER?

The Meter is the International Standard Measuring Rod—39.37 Inches in Length

Mother Earth is the mother of the meter. The French philosophers who devised this unit of measurement at the close of the eighteenth century planned that it should not be dependent upon any particular measuring stick of human construction, but instead should bear a definite relation to the dimensions of our globe. The art of measuring the earth and determining its shape, known as *geodesy*, had already made much progress, and no other people had contributed so much to it as the French. Therefore it was not strange that the authors of the metric system should have decided to take as the basis of this system a meridian of the earth's surface—a circumference passing through both poles. For greater exactness (as meridians are not all of precisely the same length) they selected a particular part of a particular meridian. They decided that a meter should be the ten-millionth part of the distance from the equator to the north pole, measured on the meridian *passing through Paris.*

COMPARING METERS AT THE U. S. BUREAU OF STANDARDS

The two meters are packed in ice, in a wooden trough. Their lengths are compared by means of a micrometer microscope

Seven years were spent in measuring an arc of this meridian, about nine and one-half degrees in length, lying between Dunkirk and Barcelona. From these measurements the length of the whole quarter meridian between the equator and the pole was computed, and a bar of platinum was constructed with the utmost care so as to have as nearly as possible one ten-millionth of this length. This was the original meter. A great many copies of it have since been made, including one that now serves as the international standard and others that have been used at various times as national standards in different countries, but the length adopted for the meter has never varied.

Meanwhile, however, the methods of geodesy have greatly improved, and we now know that the early French measurements upon which the length of the meter is based were considerably in error. The meter is about one fiftieth of one per cent shorter than it was intended to be. Hence, it can no longer be defined as the ten-millionth part of a quarter meridian. Contrary to the original plan, it is not a "natural" unit, but just as arbitrary as the foot and the yard, for it is merely the distance between two marks on a certain metal bar deposited in Paris.

The present international standard meter stick is now in the custody of the International Bureau of Weights and Measures, which is supported by the leading countries of the world. It is made of an alloy of ninety per cent platinum and ten per cent iridium—a combination that insures hardness and resistance to chemical change.

Each of the countries supporting the international bureau has two numbered duplicates of this meter, also made of platinum and iridium. Those belonging to the United States are numbered 21 and 27, and the latter has been adopted as our "primary" standard of length. Both are kept in a subterranean vault at the Bureau of Standards in Washington. About once a year this vault is opened, in order that the primary standard may be compared with a "secondary" standard. This, in turn, is occasionally compared with the "working" standards, which are used, directly or indirectly, in standardizing both metric and English measures of length for general use. Once every twenty years, or thereabouts, the primary standard is taken from the vault with elaborate precautions, packed in a special case, and carried by one of the bureau officials to Paris, where it is recompared with the international standard, in order that any microscopic change that may have occurred in its length may be detected and allowed for in its further use.

WOODEN SUSPENSION BRIDGE OVER THE MOHAWK RIVER, BUILT IN 1808
Showing it as it appeared after being enclosed with sheds in 1833

THE OLD MOHAWK BRIDGE

PIONEER SUSPENSION BRIDGE BUILT BY THEODORE BURR

The rapid development of the American colonies prior to the Revolution was due largely to the great system of waterways which gave easy access to the interior. The most important trade route was that up the Hudson and Mohawk valleys to the Great Lakes, and the early commercial supremacy of New York was due mainly to the sagacity of the early Dutch settlers in developing this great natural highway.

As population increased—and especially after the advent of the railway—rivers became an obstacle to traffic, and one of the earliest outlets of American inventive genius was that of constructing long-span bridges.

The accompanying photographs show one of the earliest and most interesting structures of this kind ever built. This was a wooden suspension bridge over the historic Mohawk, built by the celebrated engineer Theodore Burr, cousin of Vice President Aaron Burr. It is noteworthy that both of these cousins achieved prominence in American history, each expressing his genius in his own characteristic way.

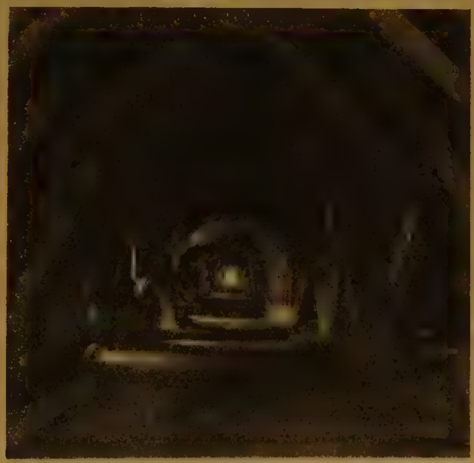
Suspension bridges consisting of a footway supported by ropes or iron chains have long been known, but the bridge here illustrated seems to have been the first successful attempt to construct a long-span wooden suspension bridge on scientific principles. It was, in fact, the pioneer and prototype of suspension bridge construction, as it was built in 1806-08, and therefore considerably antedated the work of Sir Thomas Telford and Sir Samuel Brown in England, who developed a suspension bridge constructed of iron links in 1814-30.

In Colonial days a ferry crossed the Mohawk at Schenectady, running to the foot of Ferry Street, which still retains its name. In 1800 a law was passed authorizing the construction of a bridge. This was begun in the following year, but was carried away by a flood. In 1805 a new law was passed, and under its authority the wooden suspension bridge here illustrated was designed by Theodore Burr and completed by the Mohawk Bridge Company in 1808.

This bridge was nine hundred feet long and rested on masonry river piers in addition to the land abutments. Credit for the successful completion of this work should also be given to David Hersey, a stone mason by trade, who was "boss of the job," as it is due to the thoroughness of his crafts-

manship in masonry and timber that the bridge withstood storm and freshet for two thirds of a century before it was finally torn down.

There are no photographs of the bridge when it was first constructed, for Daguerre did not invent photography until thirty years after the bridge was completed. The accompanying photograph showing the massive wooden cables was taken when the old bridge was being demolished in 1873. These cables were built up of two-inch planks of Norway pine—overlapping so as to make a continuous cable support—and when completed were each three feet wide by four feet deep. The man standing at the left of the picture gives a good idea of the massiveness of this construction, at a time when clear lumber was cheap and plentiful and structural iron and steel had not yet been invented to revolutionize the builders' art.



LOOKING THROUGH THE OLD MOHAWK BRIDGE

After many years of service the bridge became weakened by rotting timbers and lack of repair, and four additional piers were put in, one under the center of each span. These were different in design from the three original piers, as clearly apparent in the photograph.

In 1833 a succession of barn-like structures was built, enclosing the bridge and converting it into a long dark tunnel, faintly illuminated at night by four oil lamps. In time this old, weather-beaten structure, crude as it was, acquired a quaint picturesqueness that delighted the eye.

In 1872 it was finally condemned and sold to the township of Glenville, across the river from Schenectady, for $12,600, and in the following year it was demolished and replaced by an iron bridge resting on the original seven piers.

THE OLD MOHAWK BRIDGE BEING DEMOLISHED IN 1873

Showing the anatomy of the original bridge, as constructed with cables made by binding together planks of Norway pine

THE MAN WHO READS THE HEART-BEATS OF PLANTS

BY BASANTA KOOMAR ROY

Said Luther Burbank to me one day: "I deal with the life of plants, but the man who knows the most about their inner soul lives in your country, and his name is Sir Jagadis Chunder Bose."

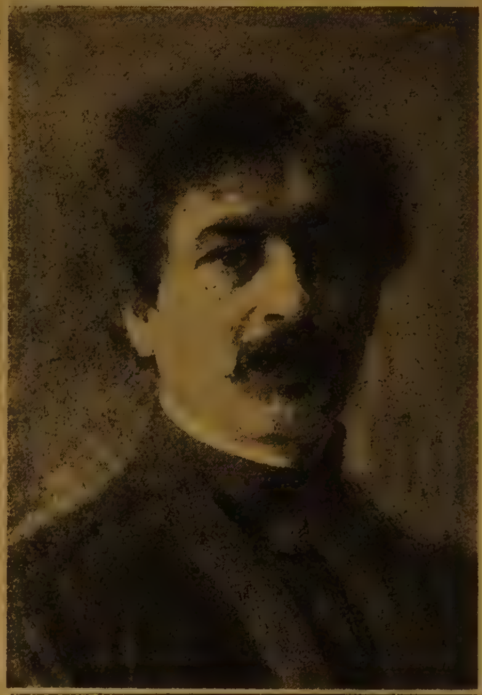
Mr. Burbank told me that he kept in close touch with the researches of Dr. Bose on the life of the seemingly non-living. Hindu sages from time immemorial have spoken and written volumes on the oneness of the universe in its diversity of manifestations. They claim that a cosmic life permeates the entire creation. The things that are apparently dead are not necessarily so. It has fallen upon Dr. Bose to prove by scientific methods and mechanical instruments the truth of India's philosophical speculations of ages ago.

Dr. Bose is not a new figure in the scientific world. It was he who gave the world the first successful experiment in wireless as long ago as 1895. In 1901 a British manufacturer of wireless apparatus offered Dr. Bose a tempting contract for his new type of receiver, but Dr. Bose refused to sell any products of his scientific researches.

While dealing with the reaction of electricity on metals he discovered that metals were quite alive; and that their tissues were as responsive to electric shocks as the tissues in animal bodies.

Gradually Dr. Bose centered his activities on the life of plants. By the invention of his amazingly delicate apparatuses he makes the hearts of plants beat like human hearts; he makes "carrots cry in agony and potatoes sing in joy." Beat an animal, and it feels the pain; drug an animal, and it is affected according to the property of the drugs. Do plants react under similar circumstances? The layman says no. But Dr. Bose records an emphatic yes. In order to prove his theory he invented his "resonant recorder."

"The principle," writes Dr. Bose, "of my resonant recorder depends on sympathetic vibration. If the strings of two violins are exactly tuned, then a note sounded on one will cause the other to vibrate in sympathy. We may likewise tune my 'vibrating writer' with a reed. Suppose the reed and the 'writer' are both tuned to vibrate a hundred times per second. When the reed is sounded the writer will also begin to vibrate in sympathy."



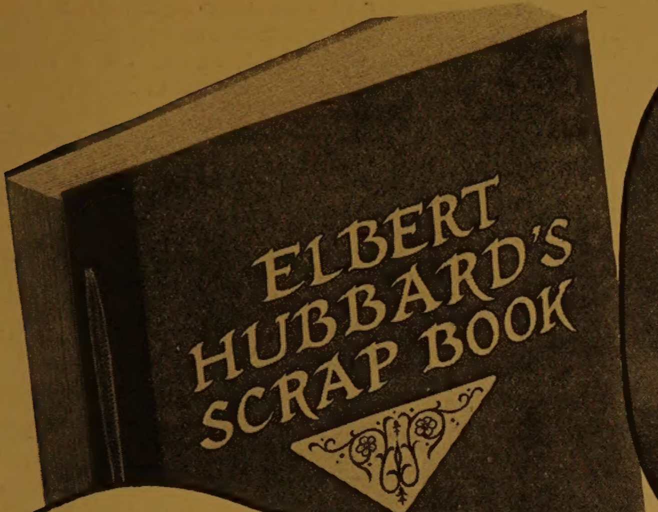
SIR JAGADIS CHUNDER BOSE
The Hindu plant physiologist who has devised several instruments by means of which he is able to detect the feelings and emotions of plants

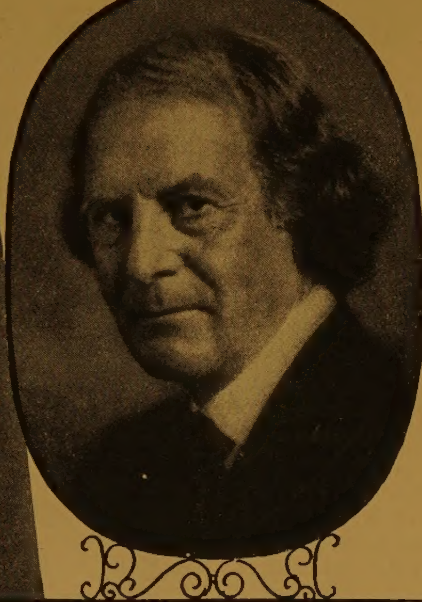
The extraordinary delicacy of this instrument will be understood when it is noted that it is possible to record a time interval as short as the thousandth part of a single heartbeat.

This instrument when attached to a carrot, a potato, or the leaf of a plant automatically records their inner emotions. How rain or drought, how cloud or sunshine, how drugs and acids affect the life of a plant is most faithfully recorded by dots on the screen.

This machine also reveals how plants have their hours of sleep and waking. Like fashionable ladies, plants keep late hours and wake up about noon. Impure air affects plants. Chloroform "dopes" plants and vegetables. Inject alcohol in a plant, and Dr. Bose shows on the screen how it will grow tipsy.

As in life, so in death. The plant, like man, shows decreasing vitality and finally refuses to respond to excitation. Then a spasm—the contractile spasm of death—passes through every fiber of its being. Thus passes away the soul of the plant—though it is not till some time after this that it begins to wither and show signs of death outwardly.





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THE MYSTERY OF THE WILL-O'-THE-WISP

BY LEON AUGUSTUS HAUSMAN

Among all the many natural phenomena that have become absorbed into the picturesque and varied story-life of civilized peoples the will-o'-the-wisp is unique. Known under a multitude of names such as *ignis fatuus*, or "vain fire," "friar's lantern," "jack-o'-lantern," "corpse candles," "death fire," "witch light," "spunkie," and many others, this mysterious phenomenon attracts consideration and study because it still lingers alluringly in the misty borderland that forever lies between superstitious fancy and attested fact.

It appears during the summer just after sunset as pale yellow, green, or bluish flames or luminous patches, usually near stagnant pools or marshy places, about two feet from the ground. The lights may be fixed in position or may waver to and fro. They have sometimes been described as flitting along the ground, or rising to considerable elevations, or circling round and round and describing other complicated motions.

CHARACTERISTIC APPEARANCE OF THE WILL-O'-THE-WISP

Along dark pools or marshes, where the fires are usually found among the reeds or bushes at the edge of the water

On April 7, 1921, at about nine in the evening, the writer was traversing a road leading through a boggy woodland near Cayutaville, New York, when he observed an unusually fine display of will-o'-the-wisp. It consisted of five separate flames, or globules, of bluish light about the size of half-dollar pieces, waveringly suspended, apparently in mid-air, among some reeds and bushes about a foot above a marshy tract of ground and about fifteen feet from the roadway. Since such lights have often been observed hovering about in the vicinity of graveyards, or even among the headstones themselves, or in dark and inaccessible marshy places (regions which are seldom explored by persons after nightfall), a host of stories and superstitions regarding their association with the spirits of the dead or with sprites, fairies, and goblins have sprung up.

So diverse have been the accounts of observers of the will-o'-the-wisp that an explanation of the phenomenon seems almost impossible. No doubt several different phenomena have been included under this name, phenomena all somewhat similar though due to widely different causes. The true will-o'-the-wisp which we have described, however, may most probably be due to the combustion of some gas produced by the decomposition of animal matter in wet ground. Some have held that this gas is the ordinary marsh gas, or methane (CH_4), but this is not spontaneously combustible, and it is difficult to conceive what agency could ignite it. Flames may be produced by phosphureted hydrogen gas (PH_3), or some similar gas, which might conceivably be generated by decaying animal tissue in a marsh. This gas the writer has synthesized in the laboratory. When allowed to come into contact with the air it ignites and burns with a pale bluish flame, which can be modified in color by the admixture of certain extraneous substances. However, no known gas can burn without giving out heat, and the experience of several observers goes to show that the flames of the *ignis fatuus* are without appreciable heat. Moreover, PH_3 burns with a characteristic and very pungent odor, and no such odor has ever been reported associated with *ignes fatui*.

The notion of some of the early observers that the friar's lantern was a phosphorescent *vapor* seems reasonable. The vapor of phosphorus is luminous, but unfortunately for the explanation this vapor has never been found occurring free in nature.

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THE MENTOR

W. D. MOFFAT
EDITOR

RUTH WOOD THOMPSON, *Assistant Editor*

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THE OPEN LETTER

JOHN ARDEN is an inmate of a state penitentiary. Some time ago he came to know about The Mentor through reading several copies that he found in the penitentiary library. John Arden is not his real name—we don't want to give his real name, for John is a "lifer." After getting acquainted with The Mentor, John Arden began to write letters to us—first asking for information, then seeking advice in the matter of reading. In one of his letters he told us something of his life, but not a word about how he came to be in prison. He has simply told us that he is twenty-three years old and that he has served two years. That's a hard situation to face—a life sentence at twenty-three! In telling about himself he sent along his photograph. He looks his twenty-three years, and no more—a fine, frank face, not a bit like a "lifer."

We became so interested in him that we wrote him letters of information and sent him books that were not in the prison library. A short time ago he wrote that he was anxious to get hold of some "good poetry." By good poetry he meant poetry of the heart—he was very plain about that. He did not want "free verse," nor didactic or dramatic poetry—he wanted poetry "that sang to the human heart." So we sent him two volumes containing a collection of the best popular poems of nature and sentiment. In reply we received the following letter. It speaks for itself.

I received the two books you sent me, and words are too puny for me to express my gratitude and appreciation. The books are wonderful. I did not think such books existed. I wish I could express the feeling that is in my heart. I might begin to express myself in actions, but I am deprived of action while here. . . . I shall cherish these books for the rest of my days; they will always be with me. Little did I think when I asked you to find a book of poems that you would find such wonderful ones.

I have been for a year looking for the aid that you are giving me, and I was beginning to get rather down-hearted, for it isn't an easy task for a prisoner to try to make something out of nothing, especially with the thought of a life sentence as a constant companion. My entry into this "hotel de luxe" has been a grand awakening to me. It showed me what a fool I was. It forced me to think of the future and review the past. I had been here a little over a year when I felt I wanted to do something. I tried to study in books. I tried mathematics—no use. I tried foreign languages, but my mind wouldn't track right. I tried mechanical drafting, and made a fairly good showing. You could at least distinguish the bolts from the nuts! Then I took a fancy to the violin. I loved its music, but knew nothing of the instrument. I watched men play it. A fellow was generous enough to give me his when he left here, and I fooled around the keyboard till I had learned enough to play some old-time tunes. Still, when I got the violin it didn't seem to fill the empty space. Then one day an artist came in and started to do some painting in the prison yard. I used to stand and watch him draw on the canvas and then cover it with paint. I was so interested that a couple of my associates offered to stake me to an outfit and see what I could do. So I got the outfit and started to try to paint. After that, when a fellow wanted a picture copied he would bring me the study and tell me to make out an order for supplies and I could keep what was left. Now nearly all my spare time is spent making pictures. I don't know why I have been telling you all this, but I guess you will be able to understand. The best I can do is to say thank you for your kindness, and it certainly does mean a lot.

John Arden tells us that he hopes to have an opportunity, within the next few years, of appearing before the parole board, and of showing cause why he should be granted a new chance in life.

W. D. Moffat
Editor